U. S. DEPARTMENT OF AGRICULTURE

FARMERS' BULLETIN No. 1761

HARVESTING *WITH* COMBINES

TROUBLE CHART

1. Loss of grain by reel and platform.
   - (*a*) Reel not set to throw cut grain well back on canvas.
   - (*b*) Reel set too high to pick up lodged grain.
   - (*c*) Reel slats too narrow.
   - (*d*) Platform backstop too low.
   - (*e*) Outer end of platform not screened.
2. Cracked grain.
   - (*a*) Cylinder speed too high.
   - (*b*) Concaves set too high or too many concave teeth.
   - (*c*) Concave, or cylinder, teeth bent or out of alinement.
   - (*d*) Concave not parallel with cylinder.
   - (*e*) Cylinder and concave clearance too small.
   - (*f*) Threshed grain returned to cylinder with tailings.
   - (*g*) End play in cylinder shaft.
3. Grain loss in straw.
   - (*a*) Unthreshed heads.
     1. Grain too damp.
     2. Cylinder speed too slow.
     3. Concaves set too low or not enough concave teeth.
     4. Concave or cylinder teeth bent or out of alinement.
   - (*b*) Threshed grain.
     1. Too much wind.
     2. Wind blast not properly directed.
     3. Cylinder and separating units running too fast.
     4. Straw agitators running too slow.
     5. Overloaded sieves.
     6. Proper sieves not used.
     7. Sieves not properly adjusted.
     8. Straw chopped up badly.
        - *a*. Too many concave teeth.
        - *b*. Concave set too high.
4. Poor cleaning.
   - (*a*) Sieve openings too large.
   - (*b*) Elevators clog.
   - (*c*) Sieves overloaded.
     1. Feed too heavy—too much straw.
     2. Speed too slow.
     3. Straw chopped up too fine.
   - (*d*) Deflectors out of adjustment.
   - (*e*) Not enough wind.
   - (*f*) Weeds.
5. Cylinder clogs.
   - (*a*) Straw, green or damp.
   - (*b*) Cylinder speed too slow.
   - (*c*) Feed too heavy—too much straw.

This bulletin is a revision of and supersedes Farmers' Bulletin 1608, The Operation and Care of the Combined Harvester-Thresher.

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HARVESTING WITH COMBINES[1]

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CONTENTS

DEVELOPMENT OF THE COMBINE

THE HARVESTING and threshing of grain were separate and distinct operations until competition demanded rapid and more economical methods. A machine was devised as early as 1828 for combining these operations, but was considered impracticable. Similar machines were built and tried out during later years, but this method of harvesting did not become commercially established until about 1880. From that date until about 1920 the use of the combined harvester-thresher, generally known as the combine, was confined largely to the States along the Pacific coast because it was believed that elsewhere crop and weather conditions were unfavorable to its use.

The demand for labor-saving machinery, together with the high price of grain, stimulated the introduction of the combine in the Great Plains States during and immediately after the World War. After the practicability of this machine had been demonstrated in the Great Plains States, it was predicted that its use would be restricted to dry areas where large-scale farming was practiced. This

[1] For helpful suggestions in preparing this bulletin and for contributing some of the illustrations the authors wish to thank the combine development committee of the American Society of Agricultural Engineers composed of the following members: Frank P. Hanson, I. D. Mayer, A. Alven, John W. Sjogren, A. B. Welty, Martin Ronning, L. A. Paradise, Walter R. Dray, C. J. Scranton, Frank N. G. Kranick, and W. M. Hurst.

did not prove to be the case, however, as the demand for a machine for harvesting soybeans in the Corn Belt soon brought combines into those States in large numbers. The recent introduction of small combines will probably again widen the field of usefulness of this type of harvester.

Much of the threshing done with the customary threshing rig has been performed by experienced operators who did mostly custom work. With the combine more farmers are operating their own machines, thereby decreasing the cost of labor. In some cases the operators are inexperienced and have trouble with their machines. In many cases breakdowns and delays might be avoided if proper precautions were taken. Frequently the combine does a poor job of threshing and cleaning because the machine is not properly adjusted.

The preparation of definite instruction for the adjustment and operation of combines of the various makes and types cannot be attempted in this bulletin because of the wide variations in crop,

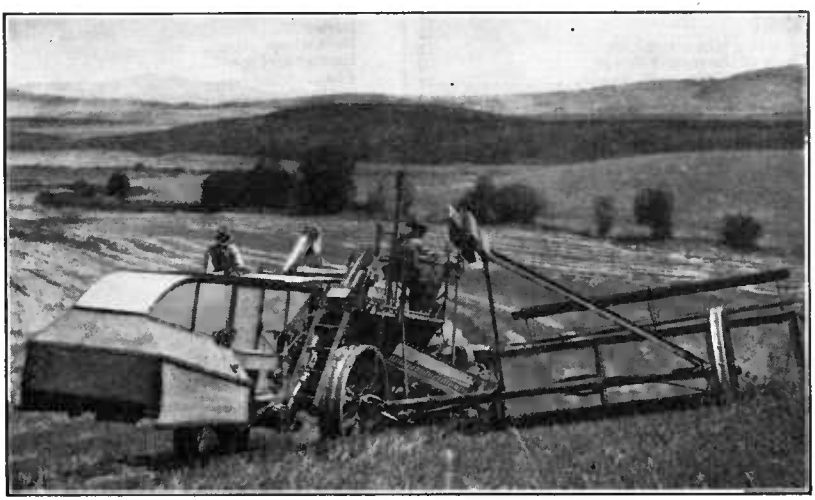

FIGURE 1.—Hillside combine.

topography, and weather conditions under which they are operated and the variations in design. However, some of the requirements for the successful harvesting and threshing of certain crops with the combine are common to all machines. The purpose of this publication is to give a clear understanding of the functions of the salient parts of a combine and the ripening characteristics of the crops harvested.

SIZES AND TYPES

Combines may be obtained in sizes ranging from a 5- to a 35-foot cut. Machines with a 10-foot cut or larger, with some exceptions, are available in either the hillside or level-land types. The hillside machines are equipped with brakes and a device for leveling the thresher to prevent the threshed grain from accumulating on one side of the sieves when it is operated on hillsides (fig. 1). The

level-land type is designed for use in areas where grades are not sufficient to greatly affect the performance of the machine.

Hillside and many level-land types have hinged headers the outer end of which is carried on a grain wheel (fig. 1) for flexibility on uneven ground. On others both the thresher and header are attached to the same frame, which is carried on wide-tread wheels. Variations also exist as to grain-handling facilities. Some machines may be obtained either with grain-bin, wagon-hitch, or grain-sacking attachment.

The small machines (5- to 8-foot cut) are usually operated by the power take-off from a tractor, though some makes may be obtained either with power take-off attachments or an engine mounted on the combine for operating all moving parts. Ten-foot and larger sizes are usually equipped with an engine. Formerly the power take-off machines did not prove entirely satisfactory in many cases, because of the lack of power on the tractor for moving the machine over the field and for operating the moving parts. In fields where the crop is heavy, and especially where low, wet spots or sand may be encountered, the load on the tractor reduces the tractor-engine speed at a time when constant speed is essential. The use of rubber tires on tractors and also on combines reduces the power required for moving the machinery over the field, leaving a larger percentage of the power available for operating the moving parts of the combine. Providing a separate clutch for the power take-off, which will enable the operator to stop the forward motion of the tractor and combine without interfering with the speed of the cylinder and other moving parts, will also make this type of equipment more practicable.

Some manufacturers use the rasp-bar or angle-bar cylinder instead of the spike-tooth type, and changes are constantly being made in the design of straw conveyors and cleaners. In the different makes and models of combines wide variations also exist in the location and arrangement of parts. To show all such variations is beyond the scope of this bulletin, and the illustrating of certain types should not be construed as implying any endorsement by the Department of Agriculture.

DESCRIPTION AND FUNCTION OF PARTS

HEADER AND PLATFORM

The header, the function of which is to cut the grain and convey it to the thresher, is composed of a reel, sickle, conveyor, and other parts making up the platform assembly. The sickle, reel, platform, and platform canvas are similar to those used on a binder or header. However, some manufacturers use sickles different from those found on binders and headers, and some use spiral conveyors instead of canvas for conveying the crop to the feeder house on the combine.

In operation the reel should usually be so set that the slats, when in their lowest position, will strike the grain 6 to 10 inches above and slightly ahead of the sickle. The exact position for the reel depends upon the height of the grain, quantity of straw cut with the grain, and the condition of the straw. The reel can usually be set so that the slats will push the cut grain well back on the platform.

If two-reel sprockets are furnished for the power-driven reel, the low-speed sprocket should be used when the combine is pulled at a speed of about 2½ miles per hour or less, unless the grain is badly lodged. The reel will frequently shatter some of the grain or throw heads over the platform if driven by the high-speed sprocket at this rate of travel. The high-speed sprocket should only be used when the grain is lodged or the combine is pulled at a speed of more than 2½ miles per hour.

The loss of grain by the reel and platform is usually very small when small grain is harvested, but may amount to as much as 25 percent of the crop when crook-necked varieties of grain sorghum are harvested, if proper precautions are not taken. A large part of this loss is due to heads which hang on the reel slats and are thrown to the ground either in front of or behind the platform. Such losses may be decreased by the use of additional boards, wire screen, or canvas to increase the width of the reel slats. Wide reel slats may also be used to advantage when nodding varieties of small grain are harvested. It is often advisable to increase the height of the platform backstop by attaching a screen-wire or canvas frame and by placing screen wire or canvas over the outer end of the platform when grain sorphum and nodding varieties of small grain are being harvested.

The extent to which the height of cut is under the control of the operator is usually sufficient for most crops. This range varies but is usually from 4 to 36 inches. Some manufacturers furnish a low-cut bar for lodged grain or crop with low-growing pods. Unless the straw is to be saved, the cutter bar should be operated as high as is possible without missing some of the heads. The cutter bar can usually be held at the desired elevation with only an occasional change, unless the grain is very uneven in height. On some machines the platform may be raised by the use of special attachments. Such changes are needed only for grain sorghum and tall sweetclover, and should not be attempted unless recommended by the manufacturer, as some parts of the machine might be subjected to undue strain.

FEEDER

The feeder on the conventional type combine receives the crop from the header and conveys it to the cylinder. Some device, usually in the form of a beater, is used for forcing the crop down against the conveyors and back into the cylinder (fig. 2).

The feeder should require little attention beyond enough to keep in good mechanical condition. Broken slats should be replaced immediately; otherwise uneven feedings and possible slugging of the cylinder may result. The drag may pull material under the feeder if the proper tension on the chains is not maintained or if the feeder board becomes warped or dented. Pitching heavy tools or parts of the combine into the feeder house while transporting the machine may dent the feeder board sufficiently to allow straw to get under the drags. The chains must also be of even length for smooth performance.

CYLINDER AND CONCAVES

The beating action of the cylinder and the rubbing action between the high-speed cylinder and the stationary concaves remove the seed

from the head or pod. Grates, either between the concaves or back of the cylinder, or both, are usually provided to allow as much as possible of the threshed seed to be separated from the straw at the cylinder.

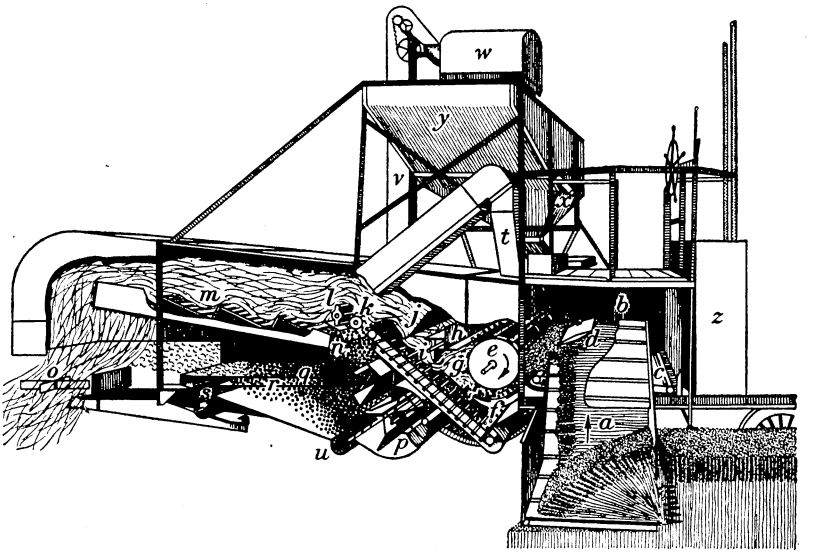

FIGURE 2.—Combine equipped with engine and grain tank: *a*, Platform canvas; *b*, feeder house; *c*, conveyor; *d*, beater; *e*, cylinder; *f*, concaves; *g*, grate; *h*, beater or stripper; *i*, grain and straw elevator; *j*, baffle; *k*, picker; *l*, agitator; *m*, straw walkers; *n*, grain return pan; *o*, straw spreader; *p*, fan; *q*, chaffer; *r*, sieve; *s*, tailings auger; *t*, tailings elevator and spout; *u*, grain auger; *v*, grain elevator; *w*, rotary weed screen; *x*, weed-screen spout; *y*, grain bin; *z*, engine.

Threshing cylinders in combines may be classified as the spike-tooth, rasp-bar, and angle-bar types. The spike-tooth cylinder is the type found in practically all threshers used in this country and in most makes of combines. The rasp-bar cylinder is in general use in threshers in Europe, and the angle-bar type is of recent development in this country.

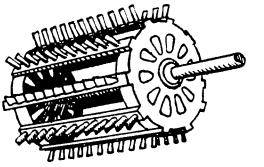

FIGURE 3.—Spike-tooth cylinder.

The spike-tooth cylinder (fig. 3) probably has a higher capacity per unit of width than either of the other types, due to the combing action of the teeth. In feeding such a cylinder, the unthreshed crop is more or less constricted in getting to the cylinder but is combed out as it passes between the cylinder and concave teeth.

With a rasp-bar cylinder (fig. 4.) the corrugations on alternate bars usually run in opposite directions. With this arrangement the crop is given a rubbing action against the concaves. Corrugated bars similar to those on the cylinder or smooth bars may be used as concaves. Rasp-bar cylinders are usually driven at a higher speed than those with spike teeth. The rasp-bar cylinder is also usually longer than the spike-tooth cylinder for a given size machine. One advantage frequently cited for the rasp-bar type is that it does not

break the straw so badly as when spikes are used, thus making it easier to separate the grain from the straw. It is also claimed that the tendency to crack the crop, especially soybeans, is minimized at high cylinder speed.

The angle-bar cylinder, a recent development, is used only on combines in which the cylinder is the entire width of the sickle and the cut crop is conveyed to the cylinder in a thin layer. Combines of this type use angle-iron bars faced with rubber. The concaves are also of rubber, as illustrated in figure 5, and are held in place by clamps. This type of cylinder is usually driven at a higher speed than either of the other types. The chief advantage claimed is that it does not break or chop up the straw, which simplifies the cleaning operation, and is less likely to clog than other types where the crop is restricted as it is fed to the cylinder. Unbroken straw is also desirable when it is to be saved for feed or bedding.

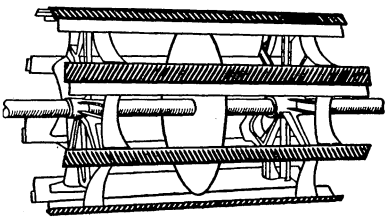

FIGURE 4.—Rasp-bar cylinder.

The cylinder of each combine is designed to operate within a certain range of speed except under special crop and harvesting conditions. The speed of the cylinder is rated in revolutions per minute. The rating varies with the different makes and models of combines but is usually about 1,000 revolutions per minute for the spike-tooth type, depending somewhat upon the diameter. The rating is such that the tips of the cylinder teeth usually travel at about 6,000 feet per minute when threshing small grain.

Dry and well-matured grain is usually comparatively easy to thresh, but if it is very dry it may, under certain conditions, crack badly. Cracking is usually caused by excessive cylinder speed, bent concave, or cylinder teeth, end play in cylinder shaft, or too little clearance between cylinder and convace teeth. It may also be caused by the use of too many concave teeth, returning an excessive quantity of threshed grain to the cylinder with the tailings, or improper concave setting.

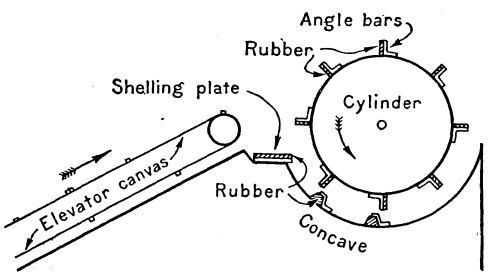

FIGURE 5.—Angle-bar cylinder with rubber-faced bars and rubber concaves. The cut grain moves back and upward from the cutter bar to the cylinder, which is the entire width of the cutter bar.

In figure 6, *A*, the cylinder teeth strike closer to the concave teeth on one side than on the other, either because of improper setting or because of end play in the cylinder. Grain may be cracked on one side and unthreshed grain be allowed to pass on the other. Bent teeth may also cause cracking in this manner. In figure 6, *B*, the concaves may be low enough to allow unthreshed grain to pass, and in figure 6, *C*, the close setting may cause cracking as well as exces-

sive breaking and chopping of the straw. Adjustments for uniform spacing (fig. 6, *D*) usually give the best results except when the crop is easy to thresh. Under such conditions the position of concaves illustrated in figure 6, *B*, may be best.

Some crops, such as soybeans and grain sorghums, are frequently cracked when the cylinder is run at rated speed, regardless of the crop conditions and the adjustments of the other parts of the combine. With such crops, especially beans, best results are possible only within a narrow speed range. Adjusting the governor on the engine to reduce the cylinder speed as much as is usually required is not advisable, because the speed of all other moving parts is reduced and the engine will not operate efficiently. Suitable pulleys, sprockets, or gears may be obtained from the manufacturer for some machines by means of which the cylinder speed may be re-

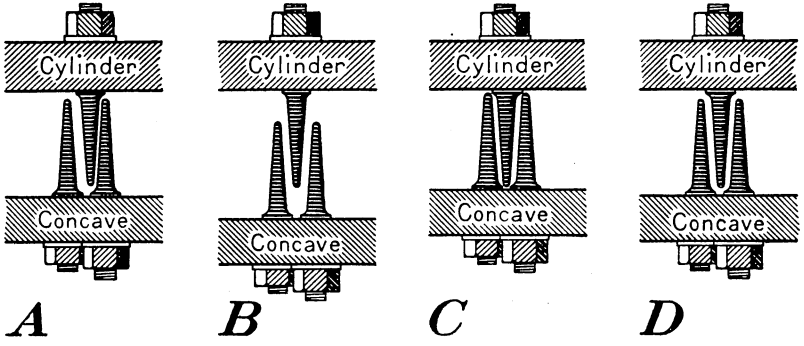

FIGURE 6.—Spacing of cylinder and concave teeth: *A*, Cylinder teeth not centered; *B*, concaves low; *C*, concaves high; *D*, uniform spacing.

duced without changing the speed of the other moving parts. This is usually accomplishd by changing the gear or pulley ratio between the engine and cylinder, and by making a suitable change in sprockets on the cylinder shaft for driving the separating units at rated speed.

The kind and quantity of the tailings returned to the cylinder is the best indication of the performance of the cylinder as well as the sieves; hence the tailings should be examined frequently. If very little threshed grain is being returned to the cylinder and cracking is evident, stop the machine and examine the cylinder and concaves for bent or loose teeth. It is usually advisable to use just enough concave teeth to thresh the grain from the heads, and keep them set low, as the straw will not be chopped up so badly and the sieve will not clog so easily. If cracking seems to be due to high cylinder speed, adjust the governor for a somewhat lower engine speed but not until other adjustments fail to produce the desired results.

Poor threshing is invariably caused by improper concave setting, badly worn or bent concave and cylinder teeth, or too low cylinder speed. A speed indicator should be used for checking the cylinder speed, as this is the only reliable method of determining the speed of a revolving shaft. The test should be made when the machine

is under load. A speed indicator may be purchased at most any hardware store at a nominal cost. If the cylinder is found to be running at rated speed and poor threshing is in evidence, stop the combine and examine the cylinder and concave teeth. Badly worn teeth not only cause poor threshing but increase the power consumption. In case poor threshing seems to be caused by the position of the concaves, raise them slightly. With tough grain it is sometimes necessary to use all of the concave teeth. In case some of the concave teeth have been previously removed, they should not be replaced until other adjustments fail to produce the desired results, as it is always best to use as few teeth as will thresh all of the grain from the heads.

SEPARATOR

A beater is usually provided just back of the cylinder for stripping the straw from the cylinder and deflecting it down against a conveyor. The loose grain is also beaten down, and, being heavier than the straw, some separating takes place at this point. The straw conveyor performs two functions—it moves the straw back away from the cylinder and agitates it to shake out threshed seed as the straw is being moved to the rear of the machine for dumping on a spreader, straw dump, or directly on the ground.

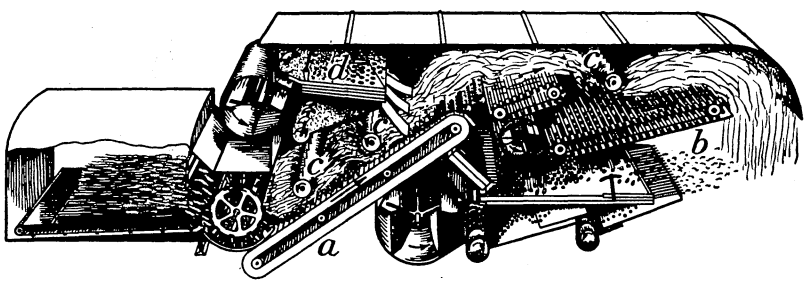

FIGURE 7.—Rotary or drag-type straw conveyor with beaters. The grain from the chaffer is elevated to the recleaner; thence it is conveyed to the bin, sacker, wagon, or truck: *a*, Straw and grain conveyor; *b*, straw conveyor; *c*, beater; *d*, recleaner.

In separating the threshed grain from the straw, straw walkers, slatted drag conveyors with beaters, rack-and-rake, or a combination of these types of conveyors are usually employed. Straw walkers (fig. 2, *m*) kick the straw upward and backward in moving it from or near the cylinder to the rear of the machine. In this type of conveyor grain shaken from the straw is returned to the chaffer on a grain pan, or on a trough attached to the walker. With the drag-conveyor type (fig. 7) beaters and agitators are provided for agitating the straw as it is moved toward the rear of the machine, and the return acts as a conveyor for dragging the grain back to the chaffer. In the rack-and-rake type (fig. 8) the straw is agitated by the vibration of a rack at the same time that it is being pushed rearward, picked up, and dropped by eccentric-mounted rakes. A drag conveyor is usually provided for conveying the grain to the chaffer as it falls through the rack.

The threshed seed, together with short pieces of straw, weed seed, chaff, and unthreshed heads or pods, are deposited upon a chaffer in the lower shoe by means of a grain carrier. This chaffer may be of mesh wire, a lip sieve, adjustable sieve, or combination of such units, and is subjected to vibration and air blast. The chaff and other such light foreign material is blown out and the unthreshed heads or pods moved to the rear, where they fall into the tailings auger and are conveyed back to the cylinder for rethreshing.

All moving parts on a separator are usually driven directly or indirectly from the cylinder and at such a speed as to give the best results under average conditions. No changes from the rated speed of straw racks, conveyors, fans, sieve vibration, or other moving parts should be attempted unless so recommended by the manufacturer.

If threshed grain is carried out with the straw it may be because of the excessive speed of the moving parts; an unduly strong air blast on the chaffer; overloaded straw agitators and chaffer; or bent, broken, or stuck baffle boards back of the cylinder. Excessive speed

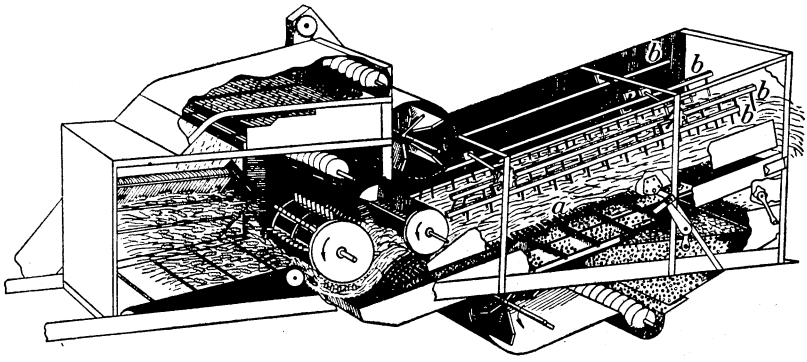

FIGURE 8.—Rack-and-rake type of straw conveyor. The straw is agitated by the rack at the same time that it is pushed rearward, picked up, and dropped by eccentric-mounted rakes: *a*, Rack; *b*, rake.

on the straw conveyor and sieves tends to discharge the straw and chaff before the grain is shaken out. If the separator is found to be running at rated speed, decrease the air blast slightly on the chaffer by adjusting the fan blinds.

Grain may be carried out with the chaff when the air blast is insufficient to keep the material on the chaffer fluffed or "alive." When a considerable amount of straw is cut it may be necessary to reduce the rate of travel or decrease the width of the swath to prevent overloading of the straw conveyors and chaffer. For best results in cleaning the chaffer should be adjusted to remove as much foreign material as possible without overloading. If the chaffer is overloaded the quantity of material may be reduced by changing the size of the openings in the straw walkers by the use of smaller mesh wire or by other means, depending upon the machine.

CLEANERS

The threshed seed, together with weed seed, short pieces of straw, and other foreign material not removed by the chaffer, fall onto a lower sieve for further cleaning by agitation and air blast or are con-

veyed to another cleaner known as a recleaner or upper shoe. From the lower sieve or the recleaner, as the case may be, the grain is conveyed to the grain bin, sacking attachment, or directly to a wagon or truck. Some manufacturers provide an additional cleaner, generally known as a rotary weed screen, for removing small weed seed from the grain. Screens are also provided in conveyors on some machines for disposing of weed seed and in others for separating threshed grain from the tailings.

The quantity of foreign material in grain has a decided bearing on the grade and market value of the grain. Weed seeds, dirt, and trash must be removed ultimately. Effective cleaning often requires considerable skill, but is usually under the control of the combine operator. Proper cleaning depends not only upon the adjustments of the sieves and fan but upon the use of proper screens and the effective operations of the entire machine.

It is advisable to use as much wind on the sieves as is possible without blowing the grain out or into the tailings auger. Oats, for example, are very much lighter than wheat and consequently require less wind. Adjustments for regulating the blast are provided for practically all conditions. Care should be exercised in adjusting so that the fan supplies air at a uniform velocity along its entire width. If one blind is opened wider than the other the distribution will not be

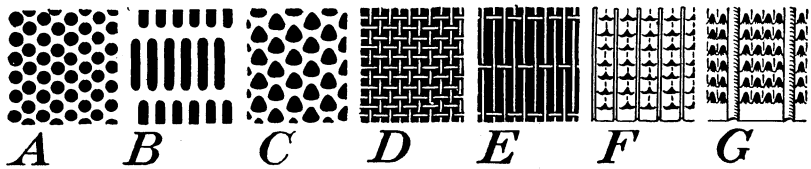

FIGURE 9.—Sieves of types commonly found in combines: *A*, Round-hole; *B*, oblong-hole; *C*, cardioid-hole; *D* and *E*, mesh-wire; *F*, lip; *G*, adjustable.

uniform and will tend under some conditions to blow grain out on one side and leave the chaff and light material with the grain on the other. It is usually best to reduce the fan speed rather than close the blinds completely, as a more uniform supply of air will result.

The type of sieves used varies widely with the type and make of machine. In some cases sieve adjustment is provided to take care of different kinds of grain as well as variations in crop conditions, and in others extra or special sieves are furnished. Figure 9 shows the most common types found in combines. The term sieve usually applies to the round-hole, oblong, woven-wire, and lip types. However, some of these may be used as screens. In this connection a sieve is used to let the grain through, but to exclude certain foreign material, whereas a screen excludes the grain but lets small weed seed and dirt through.

Cleaners, whether a part of the lower shoe or a recleaner, will usually do their best work at or below rated capacity. They are designed to take care of average conditions, and if taxed beyond this capacity on account of weeds, excessive chopping of the straw, or overfeeding (rate of travel too fast for the condition of the crop) will either throw the grain out with the straw and chaff or improperly clean it. The uniform feeding of the grain the entire width

of the cleaner is also essential. The overloading of sieves is very evident, especially with high-speed power take-off combines, when a weedy field is encountered or one in which the crop is lodged and it is necessary to handle a large mass of straw. Under such conditions, shifting from high or from plow speed to low gear on the tractor has been known to reduce the quantity of grain carried out with the straw as much as 50 percent. On machines provided with adjustments for changing the speed, length of stroke, and angle of sieves it is well to remember that optimum performance is possible within a fairly narrow speed range. If the sieve vibrates too fast, many of the kernels will bounce off or have insufficient time to get through the openings; and if the rate of vibration is too slow, the material will blanket the sieve.

In setting adjustable sieves, service men frequently first take a handful of grain and throw it on the sieve when the machine is not in operation to see if the seed will readily fall through. If the seed is retained on the sieve, it is of course necessary to open the sieve enough to permit the seed to fall through. With such a procedure fine adjustments can be made quickly after the machine has been started.

DRY GRAIN ESSENTIAL

Ripe, dry grain is one of the first essentials for the successful operation of the combine. Green or damp grain not only interferes with the threshing and cleaning operations but has a decided influence on the market value and keeping qualities of the grain. Tough straw has a tendency to clog the machine by winding on the cylinder and other moving parts, especially when they are driven below normal speed. Small particles of tough straw are difficult to remove from the threshed grain, as the straw is much heavier when damp or green. In harvesting most cereal grain the combine should not be started until the grain is dead ripe, which usually is 7 to 10 days after it is customary to begin harvesting with the binder. If the threshed grain feels damp or is easily dented with the fingernail, the moisture content is usually too high for safe storage.

No accurate, simple, and inexpensive grain-moisture tester suitable for general farm use is available. However, arrangements can sometimes be made with a local grain elevator for making moisture tests, the results of which are helpful in determining when to start the combine. The maximum moisture content of different crops for safe storage depends in part upon atmospheric conditions, storage facilities, foreign material in the grain, whether handled in bulk or in sacks, and whether the crop is for seed purposes or for market. However, standards for market grades of various crops prepared by the Bureau of Agricultural Economics can be used as a guide in this connection.[2]

Grain crops, such as winter wheat, rye, grain sorghums, rice, emmer, and spelt, containing 14 percent moisture or less, are considered dry enough for safe storage or transportation; spring wheat, oats,

[2] Handbook of Official Grain Standards of the United States, for standards in effect July 1, 1935. Handbook of Official Standards for Milled and Brown Rice, for standards in effect February 1936. United States Standards for Rough Rice, for standards in effect February 1936. [Mimeographed.] Handbook of Official U. S. Standards for Soybeans; revised, effective September 1935.

barley, when they contain not more than 14.5 percent; flax containing not more than 11 percent; and soybeans containing not more than 15 percent. The maximum moisture content for safe storage of buckwheat, field peas, and edible beans has not, so far as the authors are aware, been definitely established. However, buckwheat and field peas are acceptable on the market if they contain 16 percent of moisture and edible beans if they contain 18 percent. Many of these crops, especially beans, peas, and buckwheat, should have a moisture content lower than that indicated when stored, especially for seed purposes.

OPERATION

Because of the wide variation in crop and harvesting requirements, it is impossible to give definite rules which will be adequate under all conditions; yet many difficulties may be overcome by following general rules.

Caution: In making adjustments or working about the combine, stop the engine; keep hands and clothes away from moving parts, especially the cylinder and sickle; do not put gasoline in the tank while the engine (combine or tractor) is running; trip the impulse starter before attempting to crank the engine; and stay clear of exposed parts of the power take-off shaft. The guards provided by the manufacturers should always be used to prevent accidents.

STARTING A NEW COMBINE

Before starting a new combine, go over the machine thoroughly to see whether all bolts and nuts are tight. Be sure no tools are left in the machine or on the platform canvas or serious damage may result. Turn the cylinder and other moving parts a few turns by hand to see that everything is in good order and free to move. Trouble with a new machine is in most cases due to improper or careless setting up or lack of lubrication. Be sure all chains and belts are installed correctly, as disastrous results have occurred when some parts of the machine were driven in the wrong direction. Examine all slip clutches and make sure that none is stuck.

A new combine should not be subjected to its working load until it has been run idle for several hours. Run the engine at low speed for an hour or more before throwing the combine in gear. Run the combine at about half speed for at least an hour and at full speed for about the same length of time before starting the machine in the field. Examine the bearings frequently and keep them well lubricated. In case water in the radiator should accidentally run low and the engine overheat, shut off the ignition and turn the engine over by hand while the radiator is being filled. Pour water into the radiator slowly, as a cracked cylinder block may result from cooling the motor too quickly.

ROLE OF THE TRACTOR DRIVER

The tractor driver plays an important part in the successful operation of the combine. The machine is so designed that under average conditions each part, such as the feeder, cylinder, separator, and cleaner, will work at optimum capacity. However, as field and crop

conditions change, some part may be overloaded. If heavy down grain or green weeds are encountered, the ground speed or the width of cut should be reduced. It is also important that the crop be fed to the cylinder at a steady, uniform rate and that a full swath be taken whenever possible, for maximum daily capacity. Good tractor drivers by paying attention to the sound of the engine can, under ordinary conditions, regulate the ground speed so that the combine will operate at optimum capacity.

COMBINING IN GREEN WEEDS

Green weeds, because of their high moisture content, are comparatively heavy, and combines operating in a crop heavily infested with green weeds are subjected to unusual strain. In addition to the difficulties encountered in saving the seed under such conditions, mechanical weaknesses, frequently resulting in breakages or at least delays, occur. It is important, therefore, that the machine be in good condition and properly adjusted.

Small pieces of green weeds are very hard to separate from the crop seed. Tailings should be reduced to a minimum as the weeds will be chopped up into finer pieces each time they are returned to the cylinder. Be sure the machine is run at rated speed and that a sufficiently strong blast of air is supplied to lift the material as it passes over the chaffer. If these precautions are not taken, the weeds will tend to form a blanket over the chaffer and will invariably choke the machine. Lowering the tailboard will doubtless facilitate quick disposal of green weeds, and the loss of some grain, brought about by doing so, may be justified. Tail rakes or sieve extensions, permitting the return of much material, should be replaced by special extensions having more closely spaced tines thus reducing the amount of material falling through. The same principle may be used in the straw rack by installing fingers to reduce the amount of material returned. Free passage of the green material may be aided by fastening back the check flap above the straw rack.

The tractor driver may assist by watching the amount of material entering the feeder house and reducing the width of the swath or rate of travel if weeds are abundant. In the field shown in figure 10 it was necessary to harvest only one row of beans at a time because of rank weeds. The header operator, too, may assist materially in preventing trouble; it may be advisable to miss some grain by operating with the cutter bar above the weeds. Before starting on a badly infested field it might be well to survey the field with the object in view of harvesting only those parts from which good quality may be had with the least effort, leaving the remainder to be cut later by some other method.

COMBINING LODGED CROPS

The combine is generally recognized as particularly effective in harvesting lodged or down crops. The portion gathered, however, will depend upon the care and precautions taken. Under such conditions savings may be effected by pick-up guards and on some machines by low-cut bars. Where lodging is complete, the header must be set at its lowest position, which means that a large amount of

material will go through the machine if a full swath is taken. The ground speed should be watched carefully and kept slow enough to permit proper handling of the tangled mass by the combine. The header operator should be constantly on the lookout to prevent picking up clods, rocks, or other such foreign material.

If most of the crop has lodged in one direction, cutting operations are greatly aided if the machine travels in the opposite direction, although cutting in one direction is rarely economical because of the amount of empty travel. It may, however, be possible to apply the principle in such a way as to permit a lodged field to be cut to greater advantage.

FIGURE 10.—Harvesting a weedy field of soybeans.

In fields of lodged grain the reel may be subjected to an unusual amount of strain; if so, it would be well to reinforce the slats with wooden strips. The reel should be set lower and several inches ahead of the sickle. When the reel is set low, canvas belting is sometimes fastened at the outer edge of the reel slats to brush the cut grain back onto the platform without danger of breaking the slats. In adjusting the reel care should be taken to keep it parallel with the sickle.

WINDROWING

As combine operators and owners become more familiar with their machines and the ripening characteristics of crops on which the combine is used, there is usually less need for windrow and pick-up attachments. At the present time they are considered more as emergency than as regular equipment, except in some localities and for certain crops. A windrower is shown in operation in figure 11.

For the best results in windrowing the windrow should be supported and held above the ground by the stubble. If this is not done and wet weather follows, the crop may be damaged to a greater extent than if

left standing in the field. However, in weedy fields where the stubble will support the windrow, and for crops which do not ripen uniformly, this method can be used to advantage. For crops such as proso (hog millet), alfalfa, clovers, and certain varieties of beans and peas this is the usual method.

A mower and side-delivery rake or binder is sometimes used when the regular windrowing equipment is not available, though this practice is not generally recommended. In such cases judgment should be exercised in making the windrows to assure a uniform feed to the combine in picking up and threshing the crop. In general, each windrow should contain about the same quantity of straw as would be handled in straight combining. For example, if the combine used

FIGURE 11.—Windrowing.

in picking up the crop is designed for a cutting width of 12 feet, the windrow should be formed from a swath not to exceed this width, except possibly for oats and for other crops when the straw is light.

When the regular windrower or swather is used the combine with pick-up attachment should be driven along the windrow in the same direction as when the crop is cut. When this is done the straw is more likely to be fed to the cylinder head first. In picking up the windrow it is also important that the ground speed and that of moving parts be such as to feed the crop to the cylinder at a uniform rate.

CARE OF THE COMBINE

MANUFACTURERS' INSTRUCTIONS

Combine manufacturers usually furnish a manual giving specific instructions as to the care and operation of their machines. This manual should be studied, as the information gained may result in a saving of time, labor, and grain.

REPAIRING

Successful combine operators appreciate the importance of getting the machine in working order before harvest time. If the machine is new it should be "broken in" (p. 12) as soon as possible, because if trouble develops it can be remedied early and valuable time may thus be saved when the crop is ready for harvesting. Combines which have been used during previous seasons should be overhauled, repaired, and run for a short time several weeks before harvest actually begins. Some adjustments must be made in the field, but it is possible to have all of the parts in such condition that the necessary adjustments can be made quickly and accurately.

OILING

Before oiling a new machine, clean the paint and dirt from all the bearings and oil holes. On bearings using hard oilers force the grease in until it appears at the ends of the bearing. This forces out any dirt and insures complete lubrication of the bearing. Fill the oil cups until the space around the shaft is completely filled with oil. Manufacturers' printed instructions for the proper lubrication of their machines should be followed as the life of the machine depends in a large measure upon proper lubrication. Drive chains should not be oiled if sand or other abrasive substances are likely to accumulate on them. Chaff and particles of dust from the grain and straw, with the possible exception of those from rice, are not abrasive.

BELTS AND CANVASES

When the combine is left standing overnight exposed to the weather, remove the platform canvas and all belts or protect them from rain and dew. Old binder or header canvases can be used to cover the combine canvases and belts, or they can be removed and placed on the straw racks in the rear of the machine. If a tarpaulin is available cover the entire machine. If the platform is held in position by springs it should be set in such a position as to relieve the tension on the springs when not in use. Straw and chaff should not be left in the combine, as such material retains moisture and will cause the metal parts to rust. The greater part of the straw and chaff may be discharged by running the machine empty for a few minutes after finishing for the day.

HOUSING

Immediately after the harvest the combine should be cleaned thoroughly both inside and out and housed in a shed or barn under a good roof. Trash and dirt retain moisture and will cause metal parts to rust and wood parts to rot. All belts and canvas should be removed, kept dry, and protected from rodents. The machine (exclusive of wearing surfaces) should be given a coat of paint, and the metal parts should be coated with a heavy oil. Linseed oil should be used on the wood parts only. While cleaning the machine inspect all parts and list the repairs needed. Such a list will be very useful in ordering repairs and may save delay during the next harvest season.

If it is impossible to house the combine, remove all belts and canvases and store them. Remove the reel and hang it up in a shed to prevent the slats from being broken or warped. Paint and oil the machine, as described above. If a tarpaulin is used, tie it down in such a manner as to prevent the formation of pockets and low places where water will collect and eventually soak through and damage the machine.

Special attention should be given to the engine, as it is the most expensive part of the combine. Remove air and exhaust stacks and cover the engine to keep water out of the cylinders. Special instructions given by the several manufacturers of combines vary somewhat as to the exact procedure which should be followed in housing machines equipped with engines at the end of the harvest season, but the following recommendations are essential:

1. With a brush remove the dirt and grease from the exterior and clean it with gasoline or kerosene.
2. Drain the crankcase, refill it with fresh oil, and run the engine a few minutes so as to coat the cylinder walls and all the bearings with a film of fresh oil. If used oil is left in the crankcase, it should be drained out before the engine is started the next season.
3. Remove the spark plugs and pour approximately one-half pint of cylinder oil (not steam cylinder engine oil) or 2 or 3 tablespoonfuls of castor oil in each cylinder; turn the engine over a few times, and replace the spark plugs.
4. Drain the cooling system and leave the drain cock open.
5. Drain the fuel system if the machine is to be stored where gasoline may constitute a fire hazard.
6. Cover the engine so as to exclude water, dust, and dampness.

ORDERING REPAIRS

When ordering repairs the make, model, size, and number (if any) of the machine, as well as the description, parts' number, and quantity desired, should be given as the parts on different sizes and models are not always interchangeable. It is a good practice to give the date when the machine was purchased new, as this will help to identify the model.

COMBINE ATTACHMENTS

Auxiliary equipment for the combine has been devised and used to meet some of the various harvesting conditions in different parts of the country. Such attachments are usually extra and may be secured for some machines if justified by harvesting and threshing requirements.

GRAIN BIN, WAGON HITCH, AND SACKING ATTACHMENT

A grain bin, wagon hitch, or sacking attachment may be secured for practically all machines. The grain bin for the larger machines usually holds about 65 bushels, whereas those for the smaller sizes hold 20 to 40 bushels. These bins are emptied either by gravity or by an elevator and conveyor to a wagon or truck. When the wagon hitch is used, a wagon is attached to and drawn alongside the combine. In case the motive power is insufficient for both the grain wagon and the combine, the wagon may be pulled as a separate unit. A sacking attachment may be used in lieu of either the grain bin or wagon hitch if desired. The sacking attachment usually consists of

grain spouts and a platform with dumping device where the grain can be sacked and the sacks dumped on the ground.

PLATFORM EXTENSION

Most combines have sufficient capacity for handling a considerable quantity of straw. When the crop is light or very little straw is cut with the grain a platform and reel extension may be attached to the outer end of the platform to increase the width of the cut. Using this extension with normal to heavy crop conditions, which is sometimes attempted, will result in overloading the combine. This equipment is attached directly to the platform and reel, but the original sickle is usually replaced by one of suitable length for the longer platform.

SICKLES AND PICK-UP GUARDS

Sickles and guards designed for special crops or field conditions are available for some makes of combines. Pick-up guards for use in down and tangled grain can also be obtained.

STRAW SPREADER AND BUNCHER

The straw spreader is generally used when the straw is not needed for feed or bedding and it is desirable to have it scattered uniformly over the field. When it is desired to save the straw, a buncher may be used which dumps the straw in piles or a conveyor which windrows the straw. The straw from the buncher is usually dumped by a trip rope extending to the operator's platform. If the buncher should be overloaded, straw will accumulate in the separator, and clogging will invariably result. If neither the spreader, buncher, or conveyor is used, the straw is left in windrows behind the combine.

WINDROW HARVESTER AND PICK-UP

Windrow-harvester and pick-up attachments may be secured for several makes of combines. With this auxiliary equipment the crop may be cut and piled in windrows, picked up when dry, and threshed with the combine. Fields badly infested with weeds and crops which do not ripen uniformly have been harvested successfully by this method. Under ordinary conditions the weeds and green grass dry out in 4 to 8 days when windrowed, thus enabling the combine to do a better job of threshing and cleaning. On some machines the header is removed, mounted on a carriage, and used as a windrower or swather; a special windrower is provided by other manufacturers. The pick-up attachment is in some cases attached to the regular header on the combine and in others is supplied as a unit which is attached to the combine in place of the regular header.

EQUIPMENT FOR TRANSPORTING THE COMBINE

The header platform on large machines is usually disconnected from the side of the machine, mounted on a transport truck, and pulled behind the combine. This reduces the over-all width by approximately the length of the header platform. The platform on some of the smaller combines may be folded up and back against the

machine for transporting. The 5-foot machines are of such design as to pass through a 12-foot gate without dismantling. With the increased use of combines on small farms and for a wide variety of crops the ease of transporting the machine from field to field is of great importance. Under such conditions combines may be used in one field several times each season and transported over narrow country roads.

CROP CHARACTERISTICS AND COMBINE PROBLEMS[3]

The time of harvesting or stage of maturity at which to harvest crops with the combine for the best results is of extreme importance. New varieties are constantly being developed, but yield, quality, and resistance to diseases and insect pests are usually the primary objectives, and little consideration is given to the plant characteristics that facilitate harvesting with mechanical equipment. The Beaver and Wheatland grain sorghums, however, were developed by the Bureau of Plant Industry to obtain varieties suitable for harvesting with a combine. Farmers can eliminate many difficulties frequently encountered in harvesting with the combine by giving especial attention to the ripening characteristics of the crops and weed control. Useful information as to varietal characteristics of the crops grown in a particular part of the country can frequently be obtained from State agricultural colleges.

WHEAT

Characteristics desirable in wheats to be harvested with combines are chiefly strength of straw and resistance to lodging, uniformity of ripening, nonshattering seed habit, and erect heads of uniform height. Seldom, however, are all of the desirable characteristics found to a marked degree in one variety. Difference in maturing dates is especially important in selecting early, medium, and late maturing varieties for a continuous harvest with a minimum of delay or overlapping. Varieties susceptible to insect injury and disease should be avoided as far as possible. The use of pure seed is helpful in attaining uniformity of ripening.

Ordinarily the varieties of wheat most widely grown are those best adapted to a locality, and many of them possess qualities which make for successful harvest by the combine. New and improved varieties are continually being developed by State and Federal agencies, and efforts are being made toward the standardization by communities of the best adapted varieties. Information regarding the best varieties for a particular locality is available at many of the State experiment stations.

One of the most important considerations in harvesting wheat with combines is to know just when to start the machine in the field. A better understanding of the drying characteristic of wheat would doubtless aid in this matter, since the starting time of harvest is based mainly on the moisture content of the grain.

As wheat approaches maturity the kernel loses moisture rapidly, and after it has ripened (stopped growing) it dries out even more rapidly. Eight to ten days before wheat is ripe the kernels may con-

[3] Prepared in consultation with crop specialists in the Bureau of Plant Industry.

tain as much as 50 percent of moisture. At binder harvesttime, which is quite definitely known, the wheat may contain 30 percent or more of moisture. Obviously several days should elapse after binder harvesttime to allow the wheat to ripen, and several more days should elapse for drying before combining should be attempted. Usually from 7 to 10 days of favorable drying weather after binder harvesttime must elapse before the moisture content is low enough for safe storage, usually about 13 or 14 percent.

Ordinarily wheat that is in good condition is not difficult to combine. A cylinder speed of 1,000 revolutions per minute and the use of four rows of concave teeth is the standard set-up on most of the so-called conventional-type combines. With some varieties, Turkey for example, and under more humid conditions with other varieties, it is more difficult to knock the kernels from the heads. In such cases more concave teeth must be used. It should be remembered, however, that the least number consistent with good threshing insures cleaner and more efficient threshing with less power. Before adding more concaves, it is always a good plan to see that the concave teeth already in are in good condition and that the cylinder speed does not drop appreciably below the standard rate when the combine is working under a load. Naturally the speed of the cylinder will be slightly higher when the engine is not under load. If there is lag in the grain being fed into the cylinder, placing the blank concave in the front position may overcome the difficulty. If the wheat is being well threshed out of the head and if there is an excess of chaff and chopped straw, possibly fewer concaves may be used, they may be lowered, or the cylinder speed reduced. In reducing cylinder speed, it should be remembered that a change of speed occurs in the other working parts of the combine, and the power of the engine is reduced.

The kind, size, and number of sieves used vary somewhat with the make of combine, although the same fundamentals are used in the separation. Where the adjustable sieve is used, its proper adjustment is frequently overlooked by operators to such an extent as to defeat the purpose for which it was intended. Where the openings are too large, much material falls through the sieve before proper separation is possible; where the openings are too small, free passage of air is interrupted, with a consequent clogging of the sieve.

Wheat is the heaviest of the small grains and ordinarily requires more air blast in the separator and cleaner than other grains. The blinds of the separator shoe should be set to produce a blast strong enough to lift the chaff and light material and prevent it from falling through the sieves but not strong enough to blow the grain over.

RYE

The rye plant usually matures a few days earlier and grows considerably taller than does wheat, and consequently has a greater tendency, in the eastern United States, to lodge more, especially in unfavorable weather. If grown on soils rich in nitrogen, rye has a natural tendency to lodge. Winter rye shatters more readily than does wheat, and frequently it matures less uniformly. This is particularly true in years when the crop has not come through the winter favorably or when the spring is dry or otherwise unfavorable.

Rye tillers, therefore, often are later in their development than the main stems. In this respect all the varieties of winter rye are somewhat similar.

Rye is generally easy to thresh, and the equipment and adjustments necessary in combining wheat are usually suitable for this crop. As rye straw is usually tall, in threshing it the least possible number of concaves should be used; otherwise the straw will be badly broken up and will make unnecessary work for the sieves. When damp, rye straw tends to wrap around moving parts. For this reason the cylinder speed should be well up to normal. If by a slight increase in cylinder speed fewer concaves will do the work properly, it is well to make this adjustment.

The drooping habit of the rye head necessitates cutting more straw than would otherwise be necessary were the heads erect. When heads droop away from the direction of travel the adjustment of the reel should be watched; otherwise many of the plants, after being cut, will fall in front of the platform and be lost.

OATS

There is considerable difference in the shattering tendency of oat varieties. If grown on rich, low, poorly drained soil, oats usually produce an exceedingly rank growth of soft straw which tends to lodge badly. Abnormal vegetative growth favors rust infection and the development of other diseases in the oat plant, increasing the probability of lodging. The direct application of barnyard manure to oats may produce similar results and is rarely advisable. On soils naturally rich in nitrogen oat straw may sometimes be strengthened by use of light application of phosphorous and potash. Since lodging is a serious problem in combining oats, any means whereby it may be overcome or minimized should be taken advantage of.

Oats are early, midseason, or late maturing, according to variety. In the North Central States, which produce about four-fifths of the total crop, both early and midseason varieties are grown. Among the better varieties for combining are the Gopher, Richland (Iowa 105), and Iogold, of which the Richland and Iogold are highly resistant to stem rust. Richland has a slightly shorter and finer straw but is adapted for growing on low rich soils without lodging, so characteristic with some of the other varieties. Midseason varieties well adapted in this area are Silvermine, Green Russian, Victory, and Swedish Select. The improved midseason variety, Minota, having shorter stiff straw, is well adapted to rich soils where early varieties are less productive and the midseason varieties frequently lodge. The only late-maturing oat of importance in this area is the White Tartar, also called White Russian and Tartarian. This is very resistant to stem rust.

The oat plant will not survive delayed harvest as well as wheat or some of the other crops. It is therefore inadvisable to attempt to harvest large acreages of oats with combines unless a portion of the field is windrowed. It has been found in some areas that fewer harvesting and storing difficulties are experienced if the entire oat crop is harvested by the windrow method.

In direct combining, oats must be fully ripe before they can be threshed. Ordinarily, when all the greenness has left the straw and

the glumes have turned a dull white, combining should begin. When combined by the windrow method oats should be cut about the time the panicles turn yellow, which is the customary time to start the binder. Under normal weather conditions the panicles usually show a greenish-white color several days before turning yellow. If the oats are cut at this time there is less loss from shattering and the grain will be of good color. In districts where rains and windstorms frequently occur at oat harvesttime, it is usually better to start cutting a little early.

A dry, clean field of oats may be combined satisfactorily when one or two rows of concave teeth are used and a cylinder speed somewhat slower than for wheat. Damp oats, however, are very tough, requiring additional concaves and a cylinder speed somewhat above normal.

Special attention should be given to the amount of air on the sieves, as oats are light in weight and are easily blown out if too much air is used. The shoe-fan blinds are usually closed down one-fourth to one-half full capacity, depending upon the condition of the crop. To prevent excessive loss out the rear end, the tailboard usually should be raised to the highest position.

BARLEY

Ripe barley straw is usually brittle and crinkles down or breaks off readily or the heads break off easily. Ordinarily barley does not lodge badly. As a lodging precaution in the humid-spring region barnyard manure should never be applied directly to the crop, as such a practice usually causes a rank growth and increases the danger of lodging. Some types of barley shatter badly when ripe, while others do not. Hooded and awnless sorts shatter most easily. All barleys in humid climates shatter somewhat. The coast type (Bay Brewing, California feed, Atlas, etc.) shatters much less than other types. The types grown in the semiarid regions do not shatter readily.

The Manchuria and Oderbrucker varieties, grown in the humid-spring region, do not yield well and shatter easily when grown in semiarid regions. In determining the adaptability of varieties considerations, such as time and uniformity of maturity, shattering, lodging, and resistance to disease, have been recognized.

In direct combining barley should have a moisture content of not more than 13.5 percent when threshed, to insure safe storage. If the grain tank shows much green material the percentage of moisture should be much lower unless the green material is gotten rid of before the barley is stored.

Barley is one of the easiest crops to thresh when dry, and one of the most difficult to thresh when damp. When thoroughly dry, it may be threshed with one row of concave teeth and with a cylinder speed somewhat less than normal. When damp, the grain is hard to knock from the heads, and as many as six rows of concave teeth may be necessary. A considerable amount of light chaff is to be disposed of, including the beards and other material; where the adjustable sieve is used, it should be opened more than is necessary for wheat since better wind action on the chaffer is thus secured. Normally the same sieves used with oats are found satisfactory for combining barley.

Barley intended for malting purposes requires much more care in threshing than does that grown for feed, and its value for this purpose can be greatly affected by improper threshing. The barley kernel is protected by a heavy layer of cells that surround the starchy interior. If this layer is injured the fungi whose growth is favored in the process of malting gain entrance and feed upon the kernel. Hence, broken or skinned kernels and those whose tips have been broken off are extremely objectionable. For this reason, close threshing should be avoided.

BUCKWHEAT

Buckwheat continues to grow until checked by frost or drought; thus there may be seeds and flowers on the same plants. Unless buckwheat is harvested before frost, considerable loss is likely to occur because of the shattering. In direct combining, the judgment of the operator is necessary in determining when best to start harvest; consideration should be given to the stage at which the greatest number of mature seed may be saved. Under conditions extremely adverse to direct combining, such as heavy infestation with weeds, buckwheat may be windrowed, but this method of harvesting is usually attended with considerable shattering loss when the crop is picked up and threshed. If windrowed, the crop should be cut about the time the seed from the first lot of blossoms are fully mature, although the judgment of the operator should take precedence over any set rule as to a starting date. Losses may be reduced by cutting the crop in damp weather or when dew is on the plants.

When dry, buckwheat is easily threshed, the grain is easily cracked, and the straw is quite brittle. A comparatively slow cylinder speed (approximately 10 percent under normal) and few concave teeth are therefore requisite. Under favorable conditions, although generally one or two rows of concave teeth are used, satisfactory threshing has been accomplished with the substitution of hardwood boards for concave teeth. Such a scheme reduces the cracking hazard and at the same time aids in separating and cleaning, since the straw is less broken up by the practice. Good results are obtained with buckwheat by using the same methods and equipment as are used with wheat.

EMMER AND SPELT

Emmer and spelt are kinds of wheat that are grown to a limited extent in this country. They differ from other wheats in that most of the kernels are not removed from the chaff in threshing. The heads of both grains are easily broken at maturity. In very dry regions, where the grain becomes dead ripe, some shattering loss is probably unavoidable, especially if there is wind. Combining should start as soon as the grain has dried out sufficiently for safe storage, which is usually at a 13- to 14-percent moisture content.

No special equipment or adjustment of the combine is necessary in harvesting emmer and spelt, which are quite easily threshed under normal conditions. The machine setting and adjustments are about the same as for oats and barley, except that possibly the cylinder speed should be slower. Care should be exercised, however, to prevent knocking too many kernels from the chaff. The number and

setting of the concaves should be sufficient to completely break up the head of the plant without dehulling an appreciable number of kernels. Concave adjustment should be made to correspond to changes in the moisture content.

FLAX

All standard varieties of flax have sufficiently strong straw to stand up well. The flax plant matures at a height of from 20 to 30 inches, depending upon variety and season, and the seed of the more common varieties ripen quite uniformly. Lodging occasionally occurs with flax due to attacks of rust, which weaken the stems and cause them to fall over. Buda and the Argentine types of flax are resistant to rust, but the latter mature later and more unevenly. Bison is seldom injured by rust and on account of its resistance to wilt, is quite universally grown in the Dakotas and Minnesota. Shattering does not occur to any appreciable extent unless there are heavy winds when the crop is ripe and dry. Under normal conditions the open bolls will stand 2 to 3 weeks with but little hazard from shattering. More loss of flax in delayed harvest is likely to result from insects cutting off the bolls than from lodging or shattering.

As the flax plant approaches maturity a few of the early bolls near the base of the panicle begin to crack open; in a few days the majority of the bolls will crack open; finally the remainder will open, the whole plant will turn brown, the leaves shrivel, and the stems become dry. This habit is common to practically all of the varieties commonly grown for seed or fiber in the United States. The bolls of the Argentine strains, however, remain tightly closed when ripe. With the common varieties the ripe bolls are highly hygroscopic, the bolls opening as they dry out but closing tightly again when wet by dew or rain. This characteristic may be used as an indication of the proper condition of flax for combining, as at the open stage its moisture content is considerably under 11 percent, which is considered safe for storage.

Some varieties of flax, the Indian, Punjab (Cereal Investigation No. 20), for example, grown in California, are particularly difficult to thresh, the bolls being tightly closed when the seed is ripe. This and other varieties are frequently combined by the windrow method in California, the windrowed swath being sometimes left as long as 3 to 4 weeks before the flax is in proper condition to thresh.

Flax plants, when cut, have a tendency to bunch or cling together, especially along the front side of the platform. It should first be seen that the cutting mechanism is in as good condition as possible. The reel should be set directly over the sickle bar and as low as possible without danger of serious contact. Strips of belting or other material fastened along the outer edges of the reel slats will facilitate brushing the cut plants well back on the platform and at the same time minimize the danger of broken slats.

A cylinder speed 10 to 20 percent above normal is used in combining flax, the speed of the separating mechanism being maintained at normal by special sprockets. Four to six rows of concave teeth set high are used, depending on difficulty of threshing. If the straw happens to be dry, just as few concave teeth as will properly do the

job should be used, as with a high cylinder speed there will be a greater quantity of finely cut material going over the sieves.

Since the flaxseeds are light in weight, the direction and volume of the wind blast are important, and where special sprockets are provided for cutting down the volume of the blast they should be used. The wind board in the shoe should be adjusted so that the blast strikes the sieve as far forward as possible without resulting in the clogging of the rear portion of the sieve with chaff. If this latter condition is apparent, direct the blast more toward the middle of the sieve until it reaches a point at which the rear of the screen will stay clean. Where adjustable sieves are used they should be set somewhat closer than for wheat. The small, round-hole sieve is frequently used as a secondary sieve.

Direct combining is advised, provided the field is practically free of weeds and the flax has ripened uniformly. This method may be followed too if harvest is delayed until a few days after frost. At such a time weeds dry rapidly, and usually flax will stand for a considerable time without loss from shattering. Where fields are weedy and also where damp, cool weather delays ripening, the windrow method should be used. To avoid damage in the windrow in adverse stubble conditions, such as stubble containing Russian-thistles, flax should be picked up and threshed as soon as it is dry.

SOYBEANS

All soybean plants reach a definite size according to variety and environment and then mature and die. When the soybean plant approaches maturity the leaves begin to turn yellow and drop, and before all the pods are fully mature the leaves of most varieties have fallen. The time of harvesting will vary somewhat with weather conditions. In a hot, dry fall greater care should be taken with the varieties tending to shatter. A few varieties of the nonshattering type, such as the Biloxi, Manchu, and Mansoy, can be left until dead ripe in almost any kind of season with but little loss of seed.

Soybean harvest comes at that time of the year which is likely to be very unfavorable on account of bad weather and weed growth; hence, once the beans are ready, the harvest should go forward, if possible, without interruption. Not only is a badly lodged crop in a weedy field difficult to harvest but any beans on the ground will soon become damaged. Varieties of the Wilson, Virginia, Laredo, and Otootan types frequently lodge badly in very fertile soils and under such conditions are difficult to harvest. Figure 12 shows a combine harvesting soybeans.

Harvesting soybeans with a combine necessitates the use of special or extra equipment, which is obtainable from the several manufacturers. This includes pulleys and a belt for reducing cylinder speed, sprockets for maintaining normal speed for the rest of the separator; in some cases special sieves are recommended, although soybeans may be harvested with the regular sieve equipment used for wheat. Under some conditions pea and bean concaves are used. These permit of greater clearance between the cylinder and the concave teeth and reduce splits to a minimum.

Mature, dry soybeans are easily knocked from the pods, but, because of nonuniformity of ripening, some threshing action is needed to get

many of them. As mature, dry beans tend to crack or split as a result of the action of the cylinder, the chief problem is to harvest as much of the crop as possible with a minimum of splits. No definite rules can be laid down by which this may be accomplished. A cylinder speed about 50 percent under normal is usually found to be satisfactory. The actual speed should be the maximum at which but a reasonable number of the beans will be split, as this will insure a minimum number left in the pods. One to three rows of concave teeth are normally used, although fewer or more may be needed under extreme conditions. More air blast will be necessary than for wheat and better cleaning may result from the use of a weed screen with openings larger than those used for small grains. Because of the prevalence of down plants at harvest time, the cutting may be expedited by the use of special guards or pick-up fingers. These are bolted

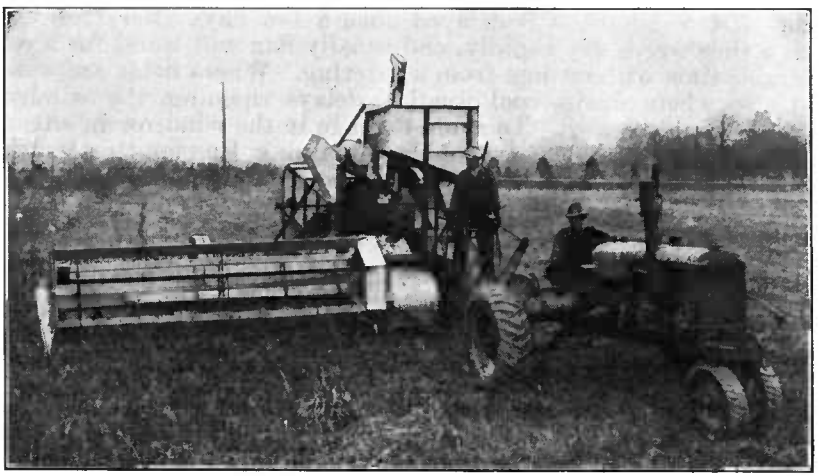

FIGURE 12.—A combine harvesting soybeans. On this machine a spiral conveyor is used on the header instead of canvas.

to the cutter bar about 1 foot apart and raise the down vines so they may be readily cut and delivered to the platform. Low-cutting bars are also available for some machines.

FIELD PEAS

Under normal conditions field peas mature uniformly. When mature the peas shell out readily; hence they cannot be left standing long after maturity without heavy loss by shelling. Direct combining cannot be attempted until the pods are sufficiently dry to be threshed with few or no concave teeth and with the cylinder speed reduced about 50 percent to minimize cracking.

In windrowing the cutting should start when the peas have become firm. It is not well to wait until the vines and pods are both dry, since, if that is done, the loss from shattering is sure to be large. If rain falls on the peas during the curing period, they should be turned over as soon as the peas in the top layer are dry. If this is not done, the peas underneath will swell and burst the pods, so that

when they become dry a great percentage will shell out and be left on the ground.

The threshing and cleaning of peas is similar to the methods and machine set-up for soybeans. In the Northwest the combine was first used as a stationary thresher; then, as windrow equipment developed, windrowing was largely used in harvesting the crop. Both stationary threshing and windrowing were attended by heavy losses of peas because of shattering due to repeated handling. More recent developments in header design have made possible direct combining with a relatively small loss of crop.

The direct combining of peas calls for special equipment and adjustments in the threshing unit and in the cutting units. A slow cylinder speed is necessary, with a minimum number of concave teeth and with the rest of the separator running at normal speed. (See soybeans, p. 25.) The standard header on the various combines was found inadequate for this crop. Several types of special pea headers are now available and are being used with a reasonable degree of success. On them the cutter bar has been lowered, and together with the reel, moved forward; guards are used to lift the vines when being cut; and on some headers a rolling colter is mounted at the end of the cutter bar to give a clean swath.

EDIBLE BEANS

Edible beans are universally cut and raked into windrows, regardless of the method of threshing. In preparing the windrow for combine pick-up, special attention should be given to the number of rows which should be bunched. The bulkiness of the crop, which, of course, will vary from year to year, and the size of the combine used in threshing are the limiting factors in determining the size of the windrow. A fairly safe rule to follow is to limit the windrow to the number of plants that could be grown on ground the same width as the cutter bar. Any doubt as to size of windrow should be resolved in favor of the smaller size because of the difficulties in handling excessive quantities of material through the machine.

Beans are normally cut when the pods have turned yellow and before they have dried out. Usually the vines are thoroughly dried out in from 2 to 3 days after cutting, when they are ready to be picked up and threshed by the combine. If rain falls while the beans are in the windrow they should be turned, preferably with a side-delivery rake. Pods should not be allowed to lie for long on the surface of wet ground, as beans readily absorb moisture and may become discolored.

Most varieties of beans are normally not difficult to thresh, but when dry they split quite easily. The problem then is primarily one of cylinder speed and concave adjustment. Usually, edible beans can be threshed with a cylinder running at from 50 to 70 percent under normal. With such a low speed, it is often necessary to employ all of the concave teeth to do satisfactory work. As is the case with soybeans, care should be exercised in providing sufficient lateral clearance between cylinder teeth and concave teeth in order to minimize cracking the beans.

The adjustment made for starting the machine in the morning, if the bean pods are damp, will doubtless need to be changed later in

the day when the pods have dried out. In adjusting for close threshing no attempt should be made to save the green, immature beans, for in so doing an adjustment may be necessary which would result in considerable splitting of the dry, mature beans. No special sieves are necessary for combining beans. The same ones used in small-grain threshing are found satisfactory.

RICE

Climatic conditions, trade preferences, and milling standards restrict to a considerable degree the varieties of rice grown in this country. From a harvesting standpoint, the varieties grown may or may not be those most suitable. On account of the conditions under which rice is grown and the variation in some of the plant characteristics seldom are all of the desirable characters embodied in any one variety. Stiffness of straw, uniformity of ripening, and resistance to lodging, shattering, and disease are important considerations in a successful harvest. On the west coast earliness of maturity is of considerable importance. Some varieties having these qualities are not grown commonly because they produce poor field or milling yields of head rice.

Since rice harvest is frequently attended by rains and unfavorable weather conditions, the importance of the resistance of the crop to lodging, shattering, and disease is obvious. Many of these hazards may be obviated in the South at times by the growing of early-maturing varieties, with due regard to yield and other important factors. The use of pure seed of the several varieties likewise will lessen the harvest problems arising from unevenness in heading and maturing.

One characteristic of the rice kernel is its tendency to become damaged by checking when subjected to hot weather and the resulting too-rapid drying. Check damage is one of the factors contributing to poor milling yield of head rice. Because of this and the possibility of lodging and shattering, the crop will not stand long after maturity without considerable loss. If the crop is allowed to stand in the field until dry enough for safe storage, the kernels will check and a low milling yield of head rice will result. Because of the heavy, green straw and the difficulty often encountered in direct combining because of wet fields, rice is frequently first windrowed and later picked up and threshed with the combine. However, this practice is not recommended for the Southern States, as the rice kernels on the windrow are likely to check badly and the crop to be damaged by wet weather. To obtain rice with a minimum number of checked kernels with the combine method, it is best to harvest the crop before the grain has dried much below 25 percent moisture and to reduce it to about 14 percent moisture by artificial drying at a low temperature.

In sections where windrowing is practiced, rice should not be left standing until fully ripe but should be cut promptly when the kernels in the lower part of the head are in the hard-dough stage. This stage of maturity is indicated by the position of the heads, which are well turned down. If the rice is cut earlier the quality will be greatly affected by a large percentage of imperfectly formed kernels. If the rice is cut later there may be a loss of grain from shattering and some checking.

In direct combining care should be exercised not to crowd the feed. Because of the heaviness of rice straw the ground speed of the machine should be slow enough to insure against clogging the machine. The rice kernel is quite susceptible to cracking, and for this reason the cylinder is run at a slightly subnormal rate. If the crop is damp and does not thresh out well, try increasing the speed slightly, being sure to watch for cracked kernels. It may be necessary to crack a small percentage of kernels in order to thresh out a maximum yield.

Reasonably dry rice is easily threshed, and the number of concaves used should be carefully watched to avoid overloading the sieves with a large mass of chopped material. In humid sections grain dries slowly after night dews; hence the condition of the grain rather than any set time should govern the starting of the machine each day. Furthermore, as the grain dries out during the day the setting of the machine will probably need to be changed for best work.

GRAIN SORGHUMS

Considerable variation exists in the stalk, head, and seed of the grain sorghums. The heads do not ripen uniformly, the grain at the top of the heads ripens about a week earlier than that at the bottom.

The heights, lodging, juiciness, and tillering habits of the stalk are important. Plants whose height is under 40 inches are considered satisfactory for combining; taller varieties are more likely to lodge and are difficult to cut. Some of the dwarf varieties, such as Wheatland, Beaver, and Double Dwarf milo, usually ranging from 20 to 36 inches in height, are especially well adapted to combining. Lodging is usually associated with tall, slender stalks and large heads, but there are varietal differences in strength of stalk. Lodging occurs after the stalk has dried out following maturity, frost, or extreme drought. Very thick stands have greater tendency to lodge than thin stands.

Tillering habits of the stalk are important because tillering results in variation in height and in uneven ripening, causing a part of the grain to be immature at harvest time. If harvest is delayed until the tiller heads are mature the main ripe heads are subjected to weathering. Varieties of kafir usually tiller less than milo or feterita but have juicy and usually tall stalks to interfere with harvest. Erect heads, such as are found on Wheatland and Beaver, give less trouble in harvesting. Double Dwarf milo normally produces many recurved heads, but when planted thick on rich irrigated land in California nearly all of the heads are erect. The head of a desirable variety for combine harvesting should extend above the leaves to permit heading without taking many leaves into the machine. The taller stalks of such varieties increase the tendency to lodge, however, and after frost or maturity the upper leaves are so dry that they scarcely interfere with threshing.

Combining should not be attempted until the grain has dried out sufficiently to be safely stored. A moisture content of 13 to 14 percent is usually considered safe. In the absence of moisture-testing apparatus there is no definite means of determining the moisture content. With experience the moisture content may be determined approximately from the "feel" of the grain, by crushing it between

the teeth, or by denting it with the thumbnail. Because of the poor drying conditions occurring usually at the time of harvest several months may elapse in extreme cases between maturity and the earliest possible harvest dates. These and less extended delays cause much of the crop to be harvested before it may be safely stored and results in much of it heating and going out of condition. Ideal conditions for harvest are provided after a severe freeze, especially after a maturing period of dry weather. Another few days of additional drying weather will considerably reduce excessive moisture in the grain so that it may be stored without danger of heating.

Wheatland and Beaver milo are adapted to western Kansas, Oklahoma, and Texas, but on account of susceptibility to chinch bug injury they are not a safe crop east of the 25-inch average annual precipitation line. A variety particularly adapted to combining which may be grown in the eastern portion of the grain sorghum area has yet to be developed.

The combine may be used either directly or as a stationary thresher to harvest grain sorghum, depending upon the conditions under which the crop is grown. When used as a stationary thresher the combine is moved up to each rick of heads. For threshing bundles of grain sorghum an upright sickle bar is rigged upon the header, the regular pitman drive being used. With such an arrangement, shocked and cured bundles of grain sorghum are laid over the sickle bar by hand so that the heads will be cut off and fed to the combine. The remaining portion of the bundle is saved for feed.

In direct combining it is important that the header platform be raised to a suitable height, depending upon the height of the crop, the reel slats widened, and screens placed at the back and ends of the platform to cut down harvesting losses.

The grain, when dry, is easily knocked out of the heads, and the chief threshing problem is to avoid cracking the grain by excessive cylinder speed. Ordinarily, a speed of from 20 to 25 percent under normal is found to result in but little if any cracking. In attaining this speed it will be necessary to change sprockets so that the rest of the mechanism runs at normal speed. The number of concaves to be used will depend entirely upon the condition of the grain. It is seldom necessary to use all the concaves. Under good threshing conditions the crop may be threshed by using two rows of concave teeth.

The stalks, leaves, and heads of grain sorghums usually contain considerable moisture when harvested. This wet material, or pomace, is frequently chopped up so that it falls through the straw racks and is too heavy to be blown out with the chaff. Consequently much of the pomace is repeatedly returned to the cylinder by the tailings elevator until it is ground fine enough to pass out with the grain. Its presence in the grain increases the danger of heating. To avoid this difficulty a piece of sheet metal should be placed over the space between the chaffer and the tailboard to prevent the pomace from falling into the tailings chute.

CLOVERS

Clovers and similar small-seeded crops are as a rule more successfully harvested with combines by the windrow method. Unfortu-

nately seeds of most clovers, when mature, shatter readily, so that extreme care should be exercised in handling the crop regardless of the method used. However, much can be done to facilitate combine harvesting by proper planting and management of the clover-seed crop. Those varieties and kinds having habits of medium plant growth, of uniform seed maturity, and of holding their seed at maturity may be combined direct.

Certain of the clovers, particularly those that develop new growth as the seed-bearing stems are maturing, are best handled by the windrow method. Regardless of the variety or kind of clover, cutting done at night or early in the morning, when the plants are wet or damp with dew, will cause less seed shattering than cutting done when the plants are dry.

Many harvesting and threshing problems are encountered in harvesting clovers and small-seed crops with combines. Large bulky plants frequently require the services of an extra man to guide or push the plants onto the platform and up into the feeder house of the machine. Also, on account of the small size and light weight of the seed, the problem of separation is especially difficult, and at times the operator must choose between obtaining a poor job of cleaning or a considerable loss of seed. As a rule, however, as much of the seed as possible should be saved; it can be recleaned later. If much damp, green material appears in the grain tank, it may be necessary to spread the seed in thin layers on the barn or granary floor for drying and reclean before storing to prevent excessive heating. In combining from the windrow the stems will be more broken in passing through the cylinder, giving the sieves greater duty, but the trash and foreign material in the grain tank will probably be comparatively dry, so that the seed may be stored with less danger of heating from this source than if stored with green material.

In threshing clovers, close concave setting, a cylinder speed somewhat above normal, and the use of special corrugated concave teeth are frequently necessary to rub the seed out of the head. This, of course, adds to the difficulty of separation on account of the finely chopped condition of the material passing over the sieves. This material should be disposed of quickly, although in so doing a few seeds may be blown out the rear end of the combine; this is better than overloading the chaffer.

The air blast is an important consideration in combining clover. The fan blinds are usually closed as far as possible to prevent blowing the seed out the rear end of the machine. Rather than shut down the fan blinds, however, special sprockets for cutting down the speed of both the shoe fan and the recleaner fan should be used, if available. The loss of seed by air blast may be corrected to a certain extent by directing the wind so that it strikes the sieve as far forward as is possible without unduly impeding its proper functioning.

Special sieves are provided for clover combining, because of the small size of the seed. Those recommended by the manufacturer should be used. Where the adjustable sieve is used, its proper setting is important. Where a recleaner is a part of the combine, see that the seed feed evenly over the sieve and that the sieve is covered

with material over a greater part of its surface. Allowing the matrial to fall through the sieve in a pile defeats the purpose of the sieve.

Since in many sections the mower and rake are employed in making the windrow, the determination of size of windrow is important. In the event of bad weather after the windrow is laid, there is the possibility that the crop will be tough and difficult to thresh. The only recourse the operator has is in slowing down the ground speed of the outfit. It is much better to have windrows too small than too large. The size of the windrow will, of course, depend upon the bulkiness of the crop and the width of the cutter bar of the combine. A fairly safe rule to follow is to limit the windrow to the quantity grown on a strip of ground as wide as the cutter bar of the combine. Hence, for a 10-foot combine a windrow bunched from two swaths of a 5-foot mower is about right.

While the combine should be watched for leaks of grain for all crops, this is especially necessary in the case of small seed. Clover seed can pass through a very narrow crack or space, and an opening sufficiently large for a kernel of wheat to pass through would be adequate for a small stream of clover seed.

SWEETCLOVER

Sweetclover is difficult to harvest for seed even under favorable conditions. This is particularly true of the biennial white, which grows to a height of from 5 to 8 feet and is very troublesome in combining because of its bulk and easily shattered seed. In producing a seed crop the growth is frequently cut for hay, pastured down until June, or the plants are clipped. Any of these treatments causes the plants to branch more freely and the seeds to mature more uniformly, which makes the crop easier to harvest. When the early growth is pastured clipping is advisable to develop uniformly maturing plants.

In the Great Plains region a comparatively thin stand of sweetclover plants is usually more productive of a good seed crop than a thick stand, and it may often be advantageous to disk the land in order to thin out the stand. However, thin stands have coarse stems and low seed-bearing branches, which make the crop more difficult to harvest with the combine.

A combine works best when the crop is dry, and at that time there is considerable loss from shattering. If combining is done at a time suitable for saving the most seed a considerable quantity of leaves, broken stems, and immature seed will need to be disposed of in the separation. A choice between direct combining and windrowing will frequently depend upon crop and weather conditions. During wet seasons harvest is sometimes delayed, and the combine is used direct. Ordinarily in windrowing much loss occurs on account of the shattering, but less green material and immature seed are obtained.

In directly combining sweetclover the reel usually needs to be slowed down and adjusted to more nearly meet the requirements of the bulky plants. The speed of the pick-up tine-bar assembly should be no greater than ground speed.

RED CLOVER

With red clover a larger and more easily handled seed crop may generally be obtained by cutting, pasturing, or clipping the first crop, and harvesting a later crop for seed. As a rule these later crops, correctly handled, are more uniform in height and maturity, produce greater yield, and are better adapted for combine harvesting than the earlier ones.

Red clover may be directly combined or harvested by the windrow method, although the latter method is preferred except during dry seasons. When the former method is used, the harvesting should start when the heads of the clover are brown. With this method there will be some loss due to heads of plants breaking off and to seed shattering. When the windrow method is used the best time to cut the clover is when the heads have turned brown, the flower stalks are deep yellow, and the seeds have begun to show a distinctly violet color. If cutting is delayed, the loss of seed from the breaking off of the heads is certain to be heavy. If the stems are heavy and full of sap, the windrowing can be done earlier than if the stems are short and dry, as an abundance of sap will ripen the seed.

CRIMSON CLOVER

Mature seed of crimson clover shatters more readily than does that of red clover. It is best combined when the heads of the plants are brown, which is indicative of maturity of the seed. At this stage the seed are easily rubbed out of the head in the palm of the hand. If there is considerable acreage to harvest and the crop is uniformly ripe there will doubtless be some field shattering before the completion of the harvest, especially in the event of rain or wind. In that case it may be well to start harvesting a little early.

In windrowing crimson clover the cutting should start about a week or 10 days after the last blossoms have faded and when the last-maturing seeds in the top of the head have reached the soft-dough stage. It is desirable that the plants be somewhat damp, as with dew, when windrowed to minimize the shattering of the seed.

ALSIKE CLOVER

When the growth of alsike clover promises to be rank, the field may be pastured until about June 1. This will cause many additional shoots to start, each of which will bear flower heads and thus increase the yield of seed. Owing to its irregular flowering habit, there will be overripe heads as well as buds on the same plant, and in directly combining the crop a loss will result from immature seeds as well as from the shattering of the mature seed. For this reason the windrow method is usually preferable. The operator's judgment should be used as to when to harvest to get the most seed.

In windrowing, the crop is usually cut when about three-fourths of the heads are ripe.

ALFALFA

On account of the uneven ripening and shattering of the seed, alfalfa is seldom directly combined. The usual method of harvest

is to cut the crop with a mower equipped with a buncher or windrow attachment (fig. 13). The self-rake reaper is sometimes used. The cutting time is very important, as if the alfalfa is cut too early there will be many immature seeds, or if it is cut too late many of the seed will be lost in shattering. The operator's judgment must be used in determining just when to cut the crop in order to save a maximum amount of seed. Usually this time is when from two-thirds to three-fourths of the seed pods have turned brown.

In threshing alfalfa special or extra machine equipment is frequently necessary for a satisfactory job. This may include, according to make of combine, special concaves with corrugated teeth, special sieves, fan sprockets for reducing fan speed, and sprockets for increasing the cylinder speed while maintaining a normal speed for

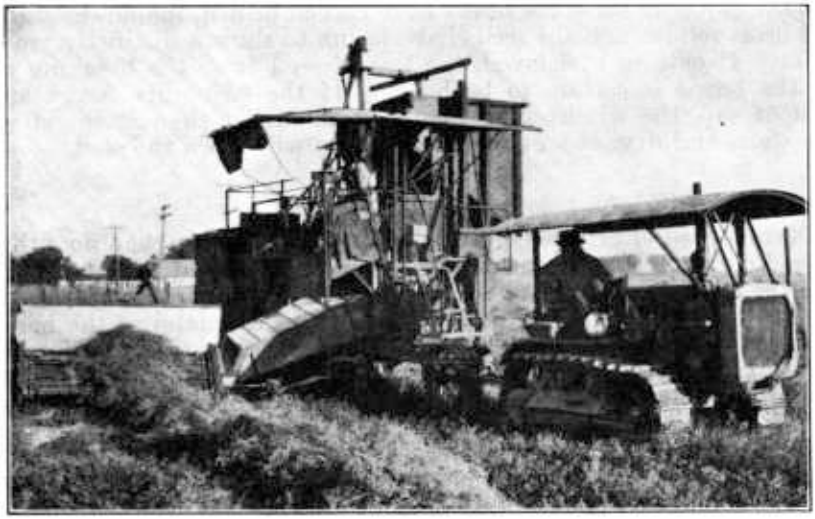

FIGURE 13.—Combining alfalfa from a windrow.

the separator. There is need for close concave setting, and the use of corrugated concave teeth is usually necessary to aid in the operation. A cylinder speed somewhat above normal is usually required, the separator speed being maintained at normal. (For additional information, see Clover, p. 30.)

LESPEDEZA

Of the annual varieties of lespedeza, Tennessee No. 76 has a more erect habit of growth than the Common or Kobe; and Korean has a distinctive seeding habit, the seeds being borne in the axils of the leaves on the ends of the branches, which probably accounts for its ability to hold mature seed much more firmly than the other varieties. This gives Korean lespedeza a decided advantage over the other varieties from a seed-harvesting standpoint, as there is considerably less loss due to shattering.

The method used in combining lespedeza will depend considerably on the condition of the crop. If it has attained sufficient height, is

fairly uniformly matured, and excessive shattering is not likely to occur, the crop may be combined direct. If this method is used, it is necessary that the seed be dry enough to be effectively threshed.

In harvesting lespedeza, particularly when the plants are short, a mower with a side-delivery clover buncher is sometimes used. If a large combine is used for picking up, two or three windrows can be raked together when damp. Or, if a wide pick-up is available, several of these small windrows can be picked up at the same time.

Seed of Common, Kobe, and Tennessee shatter readily soon after the first heavy frost in the fall, and harvesting should therefore begin as soon as possible after that time. Where the windrow method is used, the annual varieties are usually cut when the plants are brown. This work should be done when the plants are damp or wet, as with dew. Raking into windrows is best done in the late afternoon when the plants are again somewhat damp. In windrowing *Lespedeza sericea* the crop should be cut when the seeds near the tips of the growing plants are firm and before they are brown.

The seed of Korean lespedeza are readily threshed. Under favorable conditions satisfactory work has been done with a cylinder speed 40 to 50 percent under normal and with the use of plain concave teeth. Many growers object to having the seed hulled, in which case the concaves should be lowered to a degree consistent with good threshing.

TIMOTHY

Timothy has been combined successfully both directly and by the windrow method. If the crop is of uniform ripeness and free of weeds, direct combining should be done. Timothy will not stand long after maturity without shattering its seed, and if there is considerable acreage to cut it may be of advantage to windrow at least a part of it to safeguard against shattering. In windrowing the crop there is an advantage from the standpoint of safe storage, in that any heating which may otherwise occur from green material or immature seed is obviated.

Combining is ordinarily done with a normal cylinder speed and four rows of plain concave teeth. In threshing timothy it is not necessary that the seed be hulled. As a matter of fact, the hulls serve to protect the seed from the entrance of certain plant diseases where prevalent. The germination of timothy seed having hulls is usually higher, especially after the seed has been stored for several years. Where the hulls are to be retained, a slower cylinder speed may be used, with the concaves lowered.

Timothy seed is very small and light, and it is necessary that the wind blast be kept down; otherwise much seed will be blown away and lost. Sprockets for reducing the fan speed should be used, and the wind board should be adjusted in such a position that it will direct the blast to the front end of the shoe sieve.

MILLET

Millet for combine harvesting should be seeded early enough to escape the hazards and difficulties attending a very late harvest. Drying conditions are frequently a serious problem at such a time. Millet is not inclined to lodge.

Millet has been combined either directly or from the windrow, depending upon local conditions. It should be windrowed just as soon as the seed in the head can be rubbed out in the hand. The proso type of millet grown for grain (known as Hershey, Early Fortune, Manitoba, or hog millet) ripens uniformly in the head, shatters easily, and the stems and leaves remain green after the seed ripens; consequently proso is rarely combined direct. When the seed is dry it is easily threshed with a slow cylinder speed, the rest of the machine running at normal speed. When the crop is damp it is necessary, of course, to speed up the cylinder. Ordinarily close concave setting is not necessary.

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